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# Study of Paper Battery

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***Abstract:*** Traditionally, electronics have been designed around their batteries. In recent years, however, a new battery, known as the paper battery, has been developed that can easily conform to the size and shape of various electronics. The paper battery is becoming increasingly significant as technology tends towards thinner and more paper-like devices.

This paper will include a technical discussion of how the paper battery works. It will assess the efficiency and explore the advantages of recent developments in the fabrication of paper batteries. Several applications of the paper battery will then be described, and ethical issues that arise with it will be explored. This paper will illustrate how the paper battery utilizes carbon nanotubes and cellulose in its design to create a flexible battery while maintaining electrical efficiency. Further discussion will detail how the paper battery integrates the components of a typical battery into a cohesive design that is paper thin. The advantages of this design include an increased range of applicability and a simpler, more efficient fabrication process.

***Index Terms - Cathode: Carbon Nanotube (CNT), Anode: Lithium Metal (Li+), Electrolyte: All electrolytes (including bio Electrolytes like sweat, blood and urine), Separator: Paper (Cellulose)***

## I. INTRODUCTION

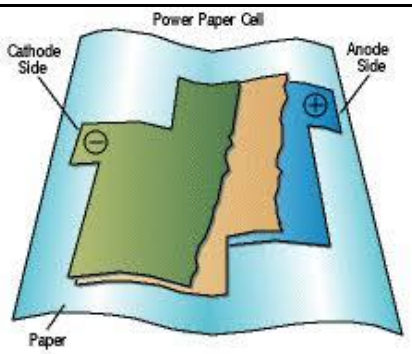
Many electronic devices and gadgets uses electrical energy, thus a power supply is required. The supply can be given by direct electricity and batteries, the batteries are the devices which are capable of storing and giving electrical energy whenever required. Batteries convert chemical energy into electrical energy, based to charging batteries are divided viz. rechargeable and non-rechargeable. But the batteries are very heavy in Weight and require large floor area.

Thus the advancement in this technology is PAPER BATTERY, it is flexible and thin energy storing device. It is made by merging the carbon nanotubes and Nano composite paper [made by cellulose]. The composition is thus inexpensive and the battery is disposable as well as biodegradable. Thus paper battery is high energy storing device and has a property like superconductor. In addition to this paper batteries are flexible and environment-friendly. The paper battery is thin, light in weight and non-corrosive and can be used almost everywhere replacing the conventional large batteries. The paper batteries can be wrapped in any shape so; the set of batteries can be used in electric cars thus the weight of vehicle will reduce to great extent. Paper batteries increase electron flow, which is very essential for high performance.

## II. *Construction*

A paper battery construction involves the following components:

- Cathode: Carbon Nanotube (CNT)
- Anode: Lithium Metal (Li+)
- Electrolyte: All electrolytes (including bio Electrolytes like sweat, blood and urine).
- Separator: Paper (Cellulose)




Construction of a paper battery mainly includes these steps:

**Step 1**: Black carbon ink is applied on a cellulose-based paper.

**Step 2**: Black Carbon ink is being spread on a paper spread on the paper.

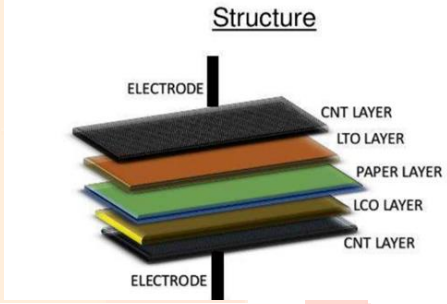
**Step 3**: A thin lithium film is laminated over the exposed cellulose surface.

**Step 4:** The cellulose paper is heated at 80oC for 5 minutes.

**Step 5:** Next, the film is peeled off from the substrate.

**Step 6**: The film acts as electrodes of the paper battery. One film is connected to the electrolyte LTO (Li4Ti5012) and another film is pasted to the electrolyte LCO (LiCo02).

**Step 7:** Next, connect a LED on both the ends of the battery and check its functionality.




Paper battery combines cellulose based paper with CNT the paper can act both high energy paper battery and super capacitor depending on the design. Cellulose is complex organic substance found in paper and pulp. CNT‟s are main ingredients of paper battery. CNT‟s where discovered by Japanese scientist name Iijima in 1991. They are now considered as top class subject in academic researches and industrial areas CNT‟s are allotropes is carbon made of graphite and have be constructed in cylindrical tubes with Nano meter scale in diameter and several millimeters in length. [2,3] Carbon nanotubes (CNTs) consist exclusively of carbon atoms arranged in a series of condensed benzene rings rolled up into a tubular structure. This novel artificial nanomaterial belongs to the family of fullerenes, the third allotropic form of carbon along with graphite and diamond which are both natural sp2 (planar) and sp3 (cubic) forms, respectively [2, 3, 4]. Based on the number of layers, structures of, CNTs are classified into two types: single-walled carbon nanotubes (SWCNTs) and multi walled carbon nanotubes (MWCNTs)

## III. *Working*

The working of Paper Battery is given as,

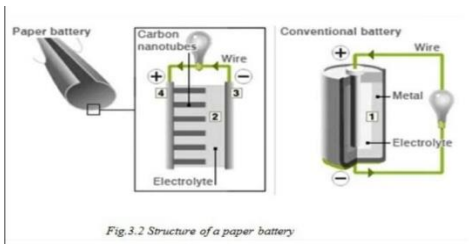



*Fig.3.2 Structure of a paper battery*

The nano tubes acting as electrodes allow the storage device to conduct electricity. Chemical reaction in battery is occurs between electrolyte and carbon nano tubes. Battery produces electrons through a chemical

reaction between electrolyte and metal in the traditional battery. Electrons must flow from the negative to the positive terminal for the chemical reaction to continue. Ionic liquid, essentially a liquid salt, is used as the battery electrolyte.

The organic radical materials inside the battery are in an “electrolyte-permeated gel state”, which is about halfway between a solid and a liquid. This helps ions to smooth move, reducing resistance, allowing the batteries to charge faster. We can stack one sheet on top of another to boost the power output. It’s a single, integrated device. The components are molecularly attached to each other: the carbon nano tube print is embedded in the paper and the electrolyte is soaked in to the paper

## IV. APPLICATION

With the developing technologies and reduction in the cost of cathode nanotubes, these batteries find applications in the following fields

**In Electronics:**

- In laptop batteries, mobile phones, handheld digital cameras: The weight of these devices can be significantly reduced by replacing the alkaline batteries with lightweight Paper Batteries, without compromising with the power requirement. Moreover, the electrical hazards related to recharging will be greatly reduced.
- In calculators, wrist watch and other low drain devices
- In wireless communication devices like speakers, mouse, keyboard, Bluetooth headsets etc.
- In enhanced PCB wherein both the sides of the PCB can be used. One for the circuit and the other side (containing the components) would contain a layer of customized Paper Battery. This would eliminate heavy step-down transformers and the need of separate power supply unit for most electronic circuits.

**In Medical Sciences**:

- In Pacemakers for the heart.
- In Artificial tissues (using Carbon nanotubes).
- In Cosmetics, Drug-delivery systems.
- In Biosensors, such as Glucose meters, Sugar meters, etc.

**In Automobiles and Aircrafts:**

- In Hybrid Car batteries.
- In Long Air Flights reducing Refueling.
- For Light weight guided missiles.
- For powering electronic devices in Satellite programs.

## V. ADVANTAGES & DISADVANYAGES

**Advantages of paper battery's**

• Non-toxic, biodegradable
• Eco friendly, biocompatible
• Easy to recycle
• Durable: shelf life of three years
• Works during extreme conditions -75°C to 150 °C
• Rechargeable
• No leakage of electrolyte
• No over heating
• Light weight and flexible
• Easily mouldable in desired shape
• Can work as super capacitor
• More power in less space
• Customizable output voltage by staking, slicing

**Disadvantages of paper battery's**

• Low shear strength can be torn easily
• CNT production technique is expensive
• Nano-toxic for CNT manufacturing workers
• Can cause fibrosis in lungs
• Aquatic like damaged by CNT

## VI. *Future Scope*

✓ It holds great potential to advance capabilities in portable power design for applications ranging from bioinstrumentation to consumer electronics and even large power systems served by conventional batteries.
✓ The paper like qualities of the material makes it especially attractive for energy storage in medically implanted devices (for example, a pacemaker, insulin pump or the implantable radio chip).

## VII. *Conclusion*

A paper battery is a paper like device formed by the combination of carbon nanotubes and a conventional sheet of cellulose-based paper which act as a flexible ultra-thin energy storage and energy production device. In addition to using the aqueous and RTIL (Room Temperature Ionic liquids) electrolytes, the device operates with a suite of electrolytes based on bodily fluids.

It suggests the possibility of the device being useful as a dry-body implant or for use under special circumstances. As a precedent, a urine-activated battery was recently demonstrated for bio-MEMS device applications. Body sweat, composed of water, Na, Cl and K ions, used as electrolyte (a drop of sweat placed on the film gets sucked into the porous cellulose) in the RTIL-free nanocomposite affords good capacitive behavior for the device (specific capacitance of 12 F/g, operating voltage of 2.4V). Blood (human whole blood in K2 EDTA from Innovative Research, Southfield, MI) worked even better as an electrolyte, enhancing the capacitive behavior of the supercapacitor, resulting in a specific capacitance of 18 F/g. As this technology is adapted it will prove

To be extremely useful and could even save not only cost but lives also.

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